

POWER SUPPLY CIRCUIT OF AN EXCITATION COIL OF AN
ELECTROMAGNET

This invention relates to a power supply circuit in direct current or rectified alternating current of an excitation coil of an electromagnet comprising at least one principal winding and one secondary winding.

5 It is known that a double winding coil may be used for an electromagnet in order to reduce the overheating of the coil and the consumption of current required for its supply. The coil includes for this purpose a call winding and a holding winding.

10 When the windings are arranged in parallel, they are both first supplied with a strong call current in order to cause the initial movement of the mobile magnetic circuit of the electromagnet, then the holding winding alone remains supplied with a weaker current so
15 as to maintain the mobile magnetic circuit in attracted position, the supply of the call winding being halted by switching.

The switching of the supply of one of these windings by electronic means after a chosen time delay
20 is known from Patent DE 2128651. However, it is difficult to control the length of time chosen for this delay. Switching may in fact take place before the closing of the magnetic circuits, in which case the electromagnet will close but will be unable to remain
25 in attracted position, or it may occur too late thereby causing the coil to overheat and leading to a slowdown in the operating output of the electromagnet.

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In consequence of which, the invention aims to provide an electronic circuit ensuring the switching of the power supply of one of the two windings of the coil only when, after closing of the electromagnet, the
5 current of the coil is very close to reaching the holding current which is sufficient to maintain the mobile magnetic circuit in attracted position.

According to the invention, the power supply circuit is characterized in that it comprises switching
10 means of a first controlled conductivity semiconductor element capable of providing or blocking the supply of the secondary winding, said means being arranged between the principal winding and the command of the semiconductor element and comprising a second
15 semiconductor element. The switching means are designed to carry out the switching of the first semiconductor element when the voltage between the command and the output of the second semiconductor element reaches a threshold voltage greater than the value corresponding
20 to the start of the closing of the electromagnet.

According to a characteristic of the invention, the switching means comprise a voltage adaptation circuit which is connected to the principal winding and to the command of the second semiconductor element, the
25 latter being connected to the command of the first semiconductor element in order to block this element when the voltage between the command and the output of the second semiconductor element reaches the threshold value.

30 The adaptation circuit advantageously comprises an RC filter made up of a resistive element and a capacitor connected in parallel, the command of the second semiconductor element being connected to an input of this circuit.



The resistive element is preferentially made up of a divider bridge equipped with two series resistors, one of the resistors being connected to the principal winding and the other resistor being placed in parallel
5 with the capacitor and connected to the supply return line of the coil.

Thus, the arrangement and constitution of the switching means make it possible to carry out with confidence the switching of the first semiconductor
10 element when the current is near to reaching the holding value after total closing of the electromagnet.

The characteristics and advantages of the invention are revealed in the ensuing description and accompanying drawings in which:

15 - Figure 1 represents the power supply circuit according to the invention;

Figures 2 and 3 represent the circuit of Figure 1 supplied in direct current according to two embodiments;

20 - Figure 4 represents the circuit of Figure 1 supplied in rectified alternating current;

- Figures 5a and 5b are graphs, illustrating in a manner known in the art, the intensity variation respectively in the principal winding and the secondary
25 winding, in function of time;

- Figure 6 is a graph illustrating the voltage variation, image of the intensity variation of Figure 5a;

- Figure 7 is a graph illustrating the voltage
30 variation at the terminals of the RC circuit provided in the voltage adaptation circuit in function of time.



The diagram visible in Figure 1 represents the power supply circuit of an excitation coil of an electromagnet according to the invention.

The electromagnet, not represented here, comprises the excitation coil, a fixed magnetic circuit and a mobile magnetic circuit designed to be attracted by the fixed magnetic circuit when the coil is supplied in current. The coil of the electromagnet is fitted with two windings, a principal winding B1 and a secondary winding B2.

The windings B1 and B2 are placed in parallel between two supply lines, an outward line a and a return line b, linked to the respective positive and negative poles of a source S of current supply. This circuit may function from a source of direct current (Figures 1 to 3) or of rectified alternating current (Figure 4).

The principal winding B1 and the secondary winding B2 are capable of activating the movement of the mobile magnetic circuit. The principal winding B1 is alone continuously supplied so as to maintain the mobile magnetic circuit in attracted position once the electromagnet is closed.

The principal winding B1 is connected in series with a resistor R1 between the supply lines a and b.

The supply of the secondary winding B2 is controlled by a controlled conductivity semiconductor element T2, for example of transistor type.

The transistor T2, of bipolar or other type, is connected to a threshold voltage circuit 20 which delivers the threshold voltage necessary to its conductivity as soon as the circuit is switched on.

In a first embodiment of the circuit supplied in direct current, as illustrated in Figure 2, the circuit 20 may consist of two resistors R3 and R4 connected in series between the lines a and b, the command of the transistor T2 being linked to the point of connection C of the two resistors.

In a second embodiment of the circuit supplied in direct current, as illustrated in Figure 3, the circuit 20 may consist of a resistor R2 and a Zener diode Z2 connected in series between the lines a and b, the command of the transistor T2 being linked to the point of connection C of the resistor and the diode.

The transistor T2 is designed to be blocked after the closing of the magnetic circuits of the electromagnet in order to cut off the power supply of the secondary winding B2. The transistor is blocked through switching means 10 arranged between its command and the principal winding B1.

The switching means 10 comprise a voltage adaptation circuit 11 and a controlled conductivity semiconductor element T1 of transistor type.

The voltage adaptation circuit 11 comprises a resistor R5 connected to the principal winding B1 and placed in series with an RC-type filter consisting of a resistor R6 and a capacitor C1 connected in parallel and linked to the return line b. This circuit constitutes a voltage integrator.

The transistor T1, of bipolar or other type, presents an input linked to the command of the transistor T2, an output linked to the return line b, and a command linked to the point of connection D between the resistor R5 and the resistor R6 of the circuit 11.

The diagram of Figure 4 represents the circuit supplied from a source of double half-wave rectified alternating current.

For this embodiment, a rectifier bridge is placed
5 between the alternating current supply source S and the power supply lines a and b of the circuit so as to supply said circuit in double half-wave rectified alternating current, each half-wave being made up of rectified sinusoids. Moreover, a smoothing appliance is
10 optionally added in order to attenuate the form of the rectified sinusoids. The appliance 30 comprises a diode D2 and a capacitor C2 placed in series between the principal winding B1 and the return line b, the resistor R5 of the circuit 11 being linked to a middle
15 point E connecting the diode D2 and the capacitor C2.

The functioning of the circuit will now be described.

As soon as a voltage is applied between the lines a and b, the current is established through, firstly,
20 the winding B1 and the resistor R1, and secondly the threshold voltage organ. The potential at the command of the transistor T2 is now instantaneously sufficient to allow the transistor to transmit the current, thereby activating the winding B2.

25 Figures 5a and 5b represent the speed of the current circulating in the principal winding B1 and in the secondary winding B2 respectively. The speed of the current circulating in the secondary winding B2 is the same as in the principal winding B1, apart from the
30 fact that the current does not take negative values. Thus, to study the image of the current in the coil, it suffices to study the speed of the current in the principal winding.

In rectified alternating current, the speed of the current is the same but the curve is made up of sinusoids. As a result, the constitution of the adaptation circuit 11 may remain unchanged in relation to that of the direct current circuit.

As is illustrated in Figure 5a, a distinction is made between two phases, the call phase A and the holding phase B; the transition between the two phases corresponds to the moment when the current is stabilized at a holding value after the closing of the electromagnet.

During the call phase A, the intensity increases through the two windings up to a value I_1 of the current, starting from which the mobile magnetic circuit moves towards the fixed magnetic circuit, causing a simultaneous reduction of the current until the closing of the electromagnetic corresponding to the time t_1 in the figure; these stages are characteristic of the first surge O_1 of the current. At the closing of the electromagnet the current increases again along a curve of exponential type which corresponds to the second surge O_2 of the current to reach the holding value I_c corresponding to the start of the holding phase B. The power supply of the secondary winding B_2 may now be cut off using the switching means 10, the adaptation circuit 11 authorizing the permutation as the electromagnet is now closed.

Figure 6 illustrates the voltage at the terminals of the resistor R_1 whose speed is the same as that of the current in the winding B_1 illustrated in Figure 5a since this voltage is representative of the image of the current in the winding B_1 . It is this voltage which is treated by the adaptation circuit 11. An image of the current circulating in the coil is therefore required; this said image is obtained by means of

measurement constituted by the resistor R1 or by a Zener diode.

Figure 7 illustrates the voltage at the terminals of the RC circuit of the adaptation circuit 11, that is to say between the command and the output of the transistor T1.

As is shown by Figures 6 and 7, during the rise of the voltage at the terminals of R1 to a maximum value V_m of the first voltage surge O1', the capacitor C1 is loaded up to a voltage value V_1 , these voltage values V_m and V_1 corresponding to the start of the movement of the mobile magnetic circuit.

The capacitor C1 is loaded without reaching its maximum capacity so that the voltage remains less than a threshold voltage V_s which corresponds to the voltage required to activate the conductivity of the transistor T1. For the value V_1 of the voltage at the terminals of the RC circuit, and thus of the voltage between the command and the output of the transistor T1, to remain less than the threshold value V_s as long as the electromagnet is not closed, steps are taken to ensure that the value V_m of the first voltage surge O1' at the terminals of R1 is less than the holding voltage V_c of the second voltage surge O2' corresponding to the holding current I_c sufficient to maintain the electromagnet closed, which is carried out through the voltage adaptation circuit 11. The two resistors R5 and R6 and the capacitor constitute an integrator which processes the voltage signal delivered at the terminals of the resistor R1 in order to adapt, from this signal, the time required to reach the activation threshold V_s of the transistor T1.

Then the capacitor C1 discharges during the voltage drop at the terminals of R1 which corresponds to the movement of the mobile magnetic circuit.

When the electromagnet is closed, the voltage at
5 the terminals of R1 rises once more, thereby causing
once again the loading of the capacitor C1. When the
capacitor reaches its maximum current-carrying
capacity, the voltage at the terminals of R1 has
reached the holding value V_c and the voltage at the
10 terminals of RC has reached the threshold value V_s ,
causing the conductivity activation of the transistor
T1 and its conductivity. The potential at the command
of the transistor T2 then collapses thereby causing its
blockage; the secondary winding B2 is therefore no
15 longer supplied and the principal winding B1 alone
continues to be supplied at a holding value of the
current. This holding value must remain sufficient
during the closing of the electromagnet so that the
capacitor remains loaded at its maximum current-
20 carrying capacity so as not to cause the voltage to
drop between the command and the output of the
transistor T1, as this would block the conductivity of
the transistor T1 and would supply anew the winding B2.

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CLAIMS



1. Power supply circuit in direct current or
5 rectified alternating current of a coil of an
electromagnet equipped with at least one principal
winding (B1) and a secondary winding (B2),
characterized in that it comprises switching means (10)
of a first controlled conductivity semiconductor
10 element (T2) capable of providing or blocking the
supply of the secondary winding (B2), and in that said
means (10) are arranged between the principal winding
(B1) and the command of the semiconductor element (T2)
and comprise a second semiconductor element (T1), the
15 latter being connected to the command of the first
semiconductor element (T2) in order to block this said
semiconductor element (T2) when the voltage between the
command and the output of the second semiconductor
element (T1) reaches a threshold voltage (V_s) greater
20 than a value (V_1) corresponding to the start of the
closing of the electromagnet.

2. Power supply circuit according to claim 1,
characterized in that the adaptation circuit (11)
comprises an RC filter made up of a resistive element
25 fitted with two resistors (R5, R6) placed in series,
and a capacitor (C1), one of the resistors (R5) being
connected to the principal winding (B1) and the other
resistor (R6) being placed in parallel with the
capacitor (C1) and linked to a return supply line (b)
30 of the coil.

3. Power supply circuit according to claim 2,
characterized in that the command of the second
semiconductor element (T1) is linked to the input (D)



of the adaptation circuit (11) between the two resistors (R5, R6).

4. Power supply circuit according to any one of the preceding claims, characterized in that the command
5 of the first semiconductor element (T2) is linked to a point of connection (C) between a resistor (R3) and a resistor (R4) connected in series between the two supply lines (a, b) of the coil.

5. Power supply circuit according to any one of
10 claims 1 to 3, characterized in that the command of the first semiconductor element (T2) is linked to a point of connection (C) between a resistor (R2) and a Zener diode (Z2) connected in series between the two supply lines (a, b) of the coil.

15 6. Power supply circuit according to any one of the preceding claims, characterized in that the two semiconductor elements (T1, T2) are transistors.

7. Power supply circuit according to any one the preceding claims, characterized in that the principal
20 winding (B1) and the secondary winding (B2) are arranged in parallel between the two supply lines (a, b) of the coil.

8. Power supply circuit according to any one of the preceding claims, characterized in that it
25 comprises means of measuring the image of the current circulating in the principal winding (B1), these means being arranged in series with said winding (B1) and in parallel with the adaptation circuit (11).